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ACQUISITION RESEARCH SPONSORED REPORT SERIES

An Experiment of the Risk Behavior of the DoD Workforce

24 October 2012

by

Dr. Donald McKeon, Professor
Defense Acquisition University (DAU)

Prepared for: Naval Postgraduate School, Monterey, California 93943

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14. ABSTRACT

This research project examines the behavior of the Department of Defense (DoD) workforce hypothesis regarding risk management in weapon system development. Two experiments were conducted to understand how the workforce approaches risk management. Many DoD programs fall behind and suffer a cost increase and schedule delay. A recent Government Accountability Office report stated, ?The total cost of DoD?s 2011 portfolio of major defense acquisition programs has grown by ? 5 percent, in the last year.?(GAO, 2012, p. 6) In addition, when compared to a program?s initial plans, the cost increase is much larger: ?When measured from their first full estimates, ? the growth in total acquisition cost for these programs is ? 40 percent.? (GAO, 2012, p. 6) Risk management is an important engineering tool for minimizing the impact of technical problems of a program. More effective risk management will lead to better managed programs. The purpose of this study is to better understand the DoD workforce?s attitude towards risk management and risk mitigation. Findings of the study will aid in improving training on risk management in order to improve the overall performance of weapon system programs. Two research experiments were run to assess the DoD workforce?s attitude to risk management. Experiments were selected to measure the participants? decisionmaking. These experiments provide an objective measure of the workforce?s attitude toward risk management. In both experiments, the participants were trying to achieve a cost target and could elect to take a risk-free approach with a fixed cost or a risk approach with a 50/50 chance of a cost increase or decrease. The first experiment showed that the DoD workforce members were risk takers and found that 42% of the time, the workforce members took risks even when they were on track to complete the project on budget. Also, the DoD acquisition workforce took risks 75% of the time when their ?program? was over budget and took risks 70% of the time even when their ?program? was under budget. The experiment also showed that there is no statistically significant relationship between years of experience and risk taking. The second experiment introduced a reward for the participants who came in under budget. The introduction of the reward had a very large impact on risk taking. The experiment found that 64% of the time, workforce members took risks even when they were on track to complete the project on time. In this case, the introduction of the reward increased risk taking by 50%. When over budget participants took risks 95% of the time, a 27% increase due to the reward. When under budget, the participants took risks 89% of the time, a 27% increase due to the reward. The experiments were not

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Abstract

This research project examines the behavior of the Department of Defense (DoD) workforce hypothesis regarding risk management in weapon system development. Two experiments were conducted to understand how the workforce approaches risk management.

Many DoD programs fall behind and suffer a cost increase and schedule delay. A recent Government Accountability Office report stated, “The total cost of DoD’s 2011 portfolio of major defense acquisition programs has grown by … 5 percent, in the last year.”(GAO, 2012, p. 6) In addition, when compared to a program’s initial plans, the cost increase is much larger: “When measured from their first full estimates, … the growth in total acquisition cost for these programs is … 40 percent.” (GAO, 2012, p. 6)

Risk management is an important engineering tool for minimizing the impact of technical problems of a program. More effective risk management will lead to better managed programs. The purpose of this study is to better understand the DoD workforce’s attitude towards risk management and risk mitigation. Findings of the study will aid in improving training on risk management in order to improve the overall performance of weapon system programs.

Two research experiments were run to assess the DoD workforce’s attitude to risk management. Experiments were selected to measure the participants’ decision-making. These experiments provide an objective measure of the workforce’s attitude toward risk management.

In both experiments, the participants were trying to achieve a cost target and could elect to take a risk-free approach with a fixed cost or a risk approach with a 50/50 chance of a cost increase or decrease. The first experiment showed that the DoD workforce members were risk takers and found that 42% of the time, the workforce members took risks even when they were on track to complete the project

on budget. Also, the DoD acquisition workforce took risks 75% of the time when their "program" was over budget and took risks 70% of the time even when their "program" was under budget. The experiment also showed that there is no statistically significant relationship between years of experience and risk taking.

The second experiment introduced a reward for the participants who came in under budget. The introduction of the reward had a very large impact on risk taking. The experiment found that 64% of the time, workforce members took risks even when they were on track to complete the project on time. In this case, the introduction of the reward increased risk taking by 50%. When over budget, participants took risks 95% of the time, a 27% increase due to the reward. When under budget, the participants took risks 89% of the time, a 27% increase due to the reward.

The experiments were not designed to identify the reasons for the risk-taking behavior exhibited by the acquisition workforce. Postulated reasons include the following: trying to get a project over-cost back on budget; being under budget and thus able to withstand a cost increase; and taking risks because of a past positive experience taking risks.

Keywords: DoD workforce, risk management, weapon system development, cost target, risk-free approach/risk approach

Acknowledgments

The author would like to thank the Naval Postgraduate School for sponsoring this work and the Defense Acquisition University (DAU) for supporting this effort.

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About the Author

Dr. Donald McKeon is a Defense Acquisition University (DAU) professor of systems engineering management and is located in Warren, MI, supporting the Tank-Automotive and Armaments Command–Life Cycle Management Command (TACOM–LCMC). Dr. McKeon teaches systems engineering, manufacturing and quality, software acquisition management, program management, and performance-based contracting. He has consulted on programs for the Air Force and the Army. Prior to joining DAU, Dr. McKeon worked in research at Sandia National Laboratories and in product development and manufacturing in private industry. Dr. McKeon has a BS, MS, and PhD in engineering and an MBA.

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Glossary of Acronyms and Terms

ACQ 450 ..... "Leading in the Acquisition Environment" course taught by DAU

ACQ 451 ..... "Integrated Acquisition for Decision Makers" course taught by DAU

ACQ 452 ..... "Forging Stakeholder Relationships" course taught by DAU

AT&L ..... Acquisition, Technology, and Logistics

BCEFM ..... Business, Cost Estimating, and Financial Management

BLRIP ..... Beyond Low Rate Initial Production Report

CON ..... Contracting

DAG ..... Defense Acquisition Guidebook

DAU ..... Defense Acquisition University

DAWIA ..... Defense Acquisition Workforce Improvement Act

DCMA ..... Defense Contract Management Agency

DoD ..... Department of Defense

DoDD ..... Department of Defense Directive

FMEA ..... Failure Mode and Effect Analysis

FY2006 ..... Fiscal Year 2006

GAO ..... Government Accountability Office

GCS ..... Ground Combat Systems

GPQ ..... Group Process Questionnaire

H_0 ..... Null Hypothesis

H_1 ..... Alternate Hypothesis

IPPD ..... Integrated Product and Process Development

IPT ..... Integrated Product Team

IT ..... Information Technology

LCMC ..... Life-Cycle Management Command

LOG ..... Logistics

LTU ..... Lawrence Technological University

MDA..... Milestone Decision Authority

MIPR..... Military Interdepartmental Purchase Request

PMT 401 ..... Program Manager's Course taught by DAU

PQM..... Production, Quality, and Manufacturing

RFI..... Request for Information

RFP..... Request for Proposal

SME..... Subject Matter Expert

SPRDE ..... Systems Planning, Research Development, and Engineering

SSCF ..... Senior Service College Fellowship Program

TACOM..... Formerly known as Tank-Automotive and Armaments Command, now called the TACOM LCMC

T&E..... Test and Evaluation

USD(AT&L)..... Under Secretary of Defense for Acquisition, Technology, and Logistics

I. Introduction

This research project examines the behavior of the Department of Defense (DoD) workforce hypothesis regarding risk management in weapon system development. Two classroom experiments were conducted to understand how the workforce approaches risk management. The results will lead to more effective training of the workforce.

A. Background

Many DoD programs fall behind and suffer a cost increase and schedule delay. A recent Government Accountability Office (GAO; 2012) report stated,

> The total cost of DoD's 2011 portfolio of major defense acquisition programs has grown by over $74 billion, or 5 percent, in the last year. The over $74.4 billion in cost growth over the past year consists of a rise in development costs of $13.7 billion, or 4 percent, and an increase in procurement costs of $60.6 billion, or 5 percent. (p. 6)

In addition, when compared to a program's initial plans, the cost increase is much larger:

> When measured from their first full estimates, which have been put in place over a number of years, the growth in total acquisition cost for these programs is $447 billion, or 40 percent. (GAO, 2012, p. 6)

Furthermore, from the same GAO (2012, p. 2) report,

> We found that most of these future programs are implementing acquisition reforms, such as competitive prototyping, early systems engineering reviews, and acquisition strategies ensuring competition or the option of competition, which have the potential to reduce risk and improve outcomes. Some of these activities require higher upfront investments in systems engineering and other areas to reduce longer term development risk, and it will be important for decision makers to sustain these investments when appropriate, even as DoD's budgetary resources shrink.

Finally, the following was written in the report:

> … overall, most of the 37 programs we assessed are not fully adhering to a knowledge-based approach, putting them at higher risk of cost growth and schedule delays.

B. Problem Statement

DoD major weapon system programs continue to experience cost overruns and schedule delays. Risk management is an important engineering tool for minimizing the impact of technical problems of a program. More effective risk management will lead to better managed programs.

C. Purpose of this Study

The purpose of this study is to better understand the DoD workforce's attitude towards risk management and risk mitigation. Findings of the study will aid in improving training on risk management in order to improve the overall performance of weapon system programs.

D. Research Hypothesis

The hypothesis of this research study is as follows:

- The DoD workforce does not make data-driven decisions in risk management.

E. Research Methodology

This research project is based on two classroom experiments on the risk-taking behavior of the DoD acquisition workforce. The first experiment involved 467 workforce members, and the second experiment involved 98 workforce members.

F. Objectives and Outcomes

The desired outcome of this research is to make recommendations on improvements to the risk management process and improvements to training on risk management and mitigation.

G. Limitations of the Study

The research project is based on a sample of 565 Defense Acquisition University (DAU) students of the 113,100[1] employees (military and civilian) in one of the Defense Acquisition Workforce Improvement Act (DAWIA) career fields. The sample size covers 0.5% of the total DAWIA population.

H. Validity of the Research

The research is based on two experiments totaling 565 DoD workforce members. The research is directly applicable to DoD programs because all participants in the experiments are in one of the DoD DAWIA career fields.

I. Reliability of the Responses

The reliability of the responses is high. The participants voluntarily participated in the experiments, and no one faced any negative consequences for participating in or not participating in this study.

[1] This is the fiscal year (FY) 2009 number.

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II. Literature Review

A. Risk

Blanchard and Fabrycky (2011, p. 690) explained risk in this way: "Risk is the potential that something will go wrong as a result of one or a series of events."

The DoD defined risk in the *DoD Risk Management Guide* (DoD, 2006, p. 1) as follows:

> Risk is a measure of future uncertainties in achieving program performance goals and objectives within defined cost, schedule and performance constraints. Risk can be associated with all aspects of a program (e.g., threat, technology maturity, supplier capability, design maturation, performance against plan [sic]) as these aspects relate across the Work Breakdown Structure (WBS) and Integrated Master Schedule (IMS). Risk addresses the potential variation in the planned approach and its expected outcome. While such variation could include positive as well as negative effects, this guide will only address negative future effects since programs have typically experienced difficulty in this area during the acquisition process.
>
> Risks have the following three components:
>
> - a future root cause (yet to happen), which, if eliminated or corrected, would prevent a potential consequence from occurring;
> - a probability (or likelihood) assessed at the present time of that future root cause occurring; and
> - the consequence (or effect) of that future occurrence.
>
> A future root cause is the most basic reason for the presence of a risk. Accordingly, risks should be tied to future root causes and their effects.

Charette (1989, p. 52) explained risk as follows:

> The definition of the word "risk" also makes a very clear statement that there will be a chance of loss associated with it. For instance, a sure loss is not a risk, because it has a certainty of occurrence. In "certainty situations," the gains and benefits can be objectively traded straightforwardly against the

losses or costs that exist. Thus, decisions are not influenced by a lack of information about the situation.

Uncertainty, on the other hand, exists in the absence of information about past, present and future events, values or conditions. This means there is a lack of confidence in the correctness of the estimated probability distribution.

Charette went on to explain, "For an event, action, thing, etc. to be considered a risk, there must be:

1. A loss associated with it
2. Uncertainty or chance involved
3. Some choice involved."

In *An Anatomy of Risk*, Rowe (1977, p. 24) said, "Risk is the potential for realization of unwanted, negative consequences of an event."

Sir David Cox made an important point (as cited in Vose, 2000, p. 47): "Variability is a phenomenon in the physical world to be measured, analyzed and where appropriate explained. By contrast, uncertainty is an aspect of knowledge."

Vose (2008, p. 48) described uncertainty as follows: "Uncertainty is the assessor's lack of knowledge … about the parameters that characterize the physical system that is being modeled."

Barkley (2004, p. xvii) explained risk management:

> Project risk management is an art, not a science. I have always been skeptical of scientific and overly quantitative answers to complex social, organizational and project outcomes, especially when customers, product and markets are involved. … Risk is no longer looked at as a single project issue. … Over emphasis on quantitative tools and mathematical models suggests RM [risk management] as a science rather than an art.

Grey (1995, p. 69) wrote,

> Human estimators will always be drawing on past experience, their own and that of other people, and adjusting it to allow for the special factors of the case they are now looking at. No estimate is untouched by human hand. Even historical data have been cleaned up and adjusted before anyone can use them.

The following are the key concepts from these sources:

- Risk includes uncertainty.
- Program risk management can't be described by a quantitative model.
- Effective risk management will draw on peoples' experiences.
- Historical data may be lacking, and even if it exists, it will have some subjectivity built into the data.

B. Risk Management Experiments Involving the DoD Acquisition Workforce

Past research projects involving experimentally measuring the risk behavior of the DoD workforce have not been found.

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III. Research Methodology

A. Research Hypothesis

The hypothesis of this research study is as follows:

- The DoD workforce does not make data-driven decisions in risk management.

B. Research Experiments

Two research experiments were run to assess the DoD workforce's attitude to risk management. Experiments were selected to measure the actual decisions made by the participants. These experiments provide an objective measure of the workforce's attitude toward risk management.

Both experiments were designed to measure the participant's decision-making behaviors when faced with uncertain outcomes. The second experiment also included a small reward to determine if a reward impacted the findings of the first experiment.

1. Experiment #1

The first experiment was completed by 467 DoD acquisition workforce members attending a DAU class. The experiment was run in 14 DAU classes from March 22, 2011, to September 12, 2011. Classes included ACQ-201B, SYS-302, SAM-301, IRM-304, BCF-211, LOG-350, LOG-236, and CON-215[2]. The experiment took about 10 minutes to complete, and participants kept track of their decisions on forms that the researcher then used to analyze their decision-making.

Students also provided their DAWIA career field and their number of years of work experience.

[2] Refer to the Glossary of Acronyms and Terms for the titles of the DAU courses.

In Experiment #1, each student was faced with six decisions.[3] The student started with zero actual costs and had six periods (months) of expenses. If the participant selected a risk-free approach, the period's expense was $10. Therefore, if the student took the risk-free approach for all six decisions, the student would have accumulated a total expense of $60.

However, at each decision point, the student could elect to take on risk to try and reduce the expense for the period. A realistic scenario for this situation might be the adoption of new technology to meet an aggressive schedule, reduce costs, or achieve a challenging performance target.

At each decision point, the student could select the risk-free or risk-taking approach. That is, the students were free to change their strategy at each of the six decision points.

If the participant decided to take on risk, there was a 50% probability (p = 0.5) that the month's expenses would be $5 and a 50% probability that they would be $20. When risk is taken, the expected outcome[4] is $12.50. Hence, on average, participants will lose money if they take on risk. Since there are only six periods, some students will "beat" the odds and come in under budget, while others will be over budget.

An additional part of the experiment was the target total cost. Fifty percent (50%) of the students had a target cost of $55, while the remainder had a target cost of $60. Therefore, someone not taking risk would only be on budget if they had a target of $60 but would be over budget if they had a target cost of $55.

---

3 In the experiment, each decision was for one month of a program.

4 Expected outcome is what the outcome would be if a very large number of trials were undertaken. In this case, the expected outcome is 0.5*$5 + 0.5*$20.

There wasn't a reward offered in the exercise, although the vast majority of the students took the experiment seriously and enjoyed the exercise (based on observations, comments from students, and comments from instructors).

2. Experiment #2

The second experiment was designed to validate the results of the first experiment regarding risk/rewards. The experiment was run for three classes from October 3, 2011, until March 25, 2012. Ninety-eight (98) students participated from an ACQ-201B, SAM-301, and SYS-203 class.[5]

The experiment took about 10 minutes to complete, and participants kept track of their decisions on forms that the researcher then used to analyze the results. Students also provided their DAWIA career field and their number of years of work experience.

The target total expense for all of the participants in Experiment #2 was $50 (this differed from Experiment #1).

Each participant was faced with five decisions. The participant started with zero actual costs and had five periods of expenses. If a risk-free approach was taken, each period's expense was $10. Therefore, if the participant took the risk-free approach for all five decisions, the participant would accumulate a total expense of $50 and would meet the cost target.

However, at each decision point, the participant could elect to take on risk to try and reduce the actual expenses. When the participant took risk, there was a 50% probability ($p = 0.5$) that the month's expenses would be $8, and there was a 50% probability that they would be $14. The expected outcome was $11. The range of expenses was from $40 to $70.

[5] Refer to the Glossary of Acronyms and Terms for the titles of the DAU courses

At each decision point, the participant could select the risk or risk-free approach. That is, the participants were free to change their strategy at each of the five decision points.

Therefore, if the participant took the risk-free approach for all five decisions, they met their budget target of $50. However, if they took risk for each period, the participants would be over budget by an average of $5. Since there were only five trials, some participants "beat" the odds and came in under budget, while others were over budget.

There was a small reward offered to people who met or came in under the target expense of $50 or lower. There was an incentive to at least meet the target expense of $50. Rewards ranged from PEZ candy dispensers to coffee mugs. The person with the lowest total expense was the first to select a prize.

C. Data Collection

All participants recorded their decisions on a form handed out at the beginning of the experiment. After completing the experiment, the researcher entered the data into an Excel file for analysis. Data recorded included the participant's career field and the number of years of professional experience (post-college).

IV. Data Analysis

In this section, the raw data from the experiments are presented. Findings of the research are presented in Chapter 5.

Two research experiments were run to assess the DoD workforce's attitude to risk management. Experiments were selected to measure the participants' decision-making. These experiments provide an objective measure of the workforce's attitude toward risk management.

The following sub-sections present the data from the two experiments.

A. DoD Acquisition Workforce by Career Field

The distribution of the DoD acquisition workforce by career field is shown in Figure 1 (Office of the Under Secretary of Defense for Acquisition, Technology, & Logistics [OUSD(AT&L)], 2012, p. 5). There are over 151,000 members in the acquisition career fields. The percentages of each career are as follows:

- Research & Engineering (SPRDE): 28%
- Contracting (CON): 20%
- Program Management (PM): 11%
- Logistics (LOG): 11%
- Production, Quality, & Manufacturing (PQM): 6%
- Test & Evaluation (T&E): 6%
- Business Cost Estimating and Financial Management (BCEFE or BCF): 5%
- Information Technology (IT): 4%

- All others[6]: 9%

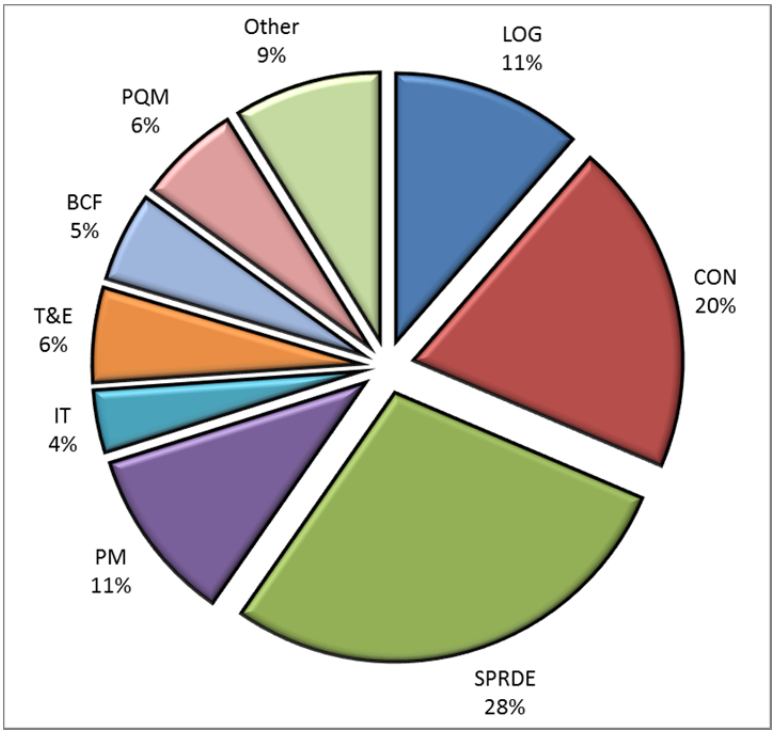

Figure 1. Breakdown of the Total DoD Acquisition Workforce by Career Field

1. Experiment #1—Participants by Career Field

The distribution of the participants by career field for Experiment #1 is shown in Figure 2. The distribution for Experiment #1 was higher for SPRDE, LOG, and IT and lower for CON and PM, compared to the overall population of the DAWIA workforce.

6 Other includes auditing, facilities engineering, industrial property, and purchasing.

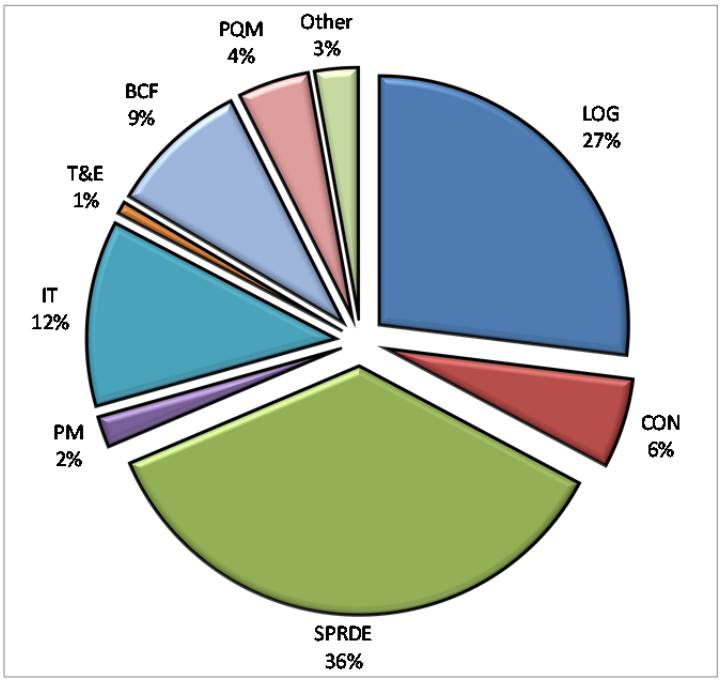

Figure 2. Breakdown of Participants by Career Field for Experiment #1

2. Experiment #1—Participants by the Number of Years of Experience

The total number of years of professional experience, either as a government civilian, military, or in any industry, averaged 17.7 years. The distribution is shown in Figure 3. Forty-two percent (42%) had 21 or more years of experience. Only 6% had less than two years of experience.

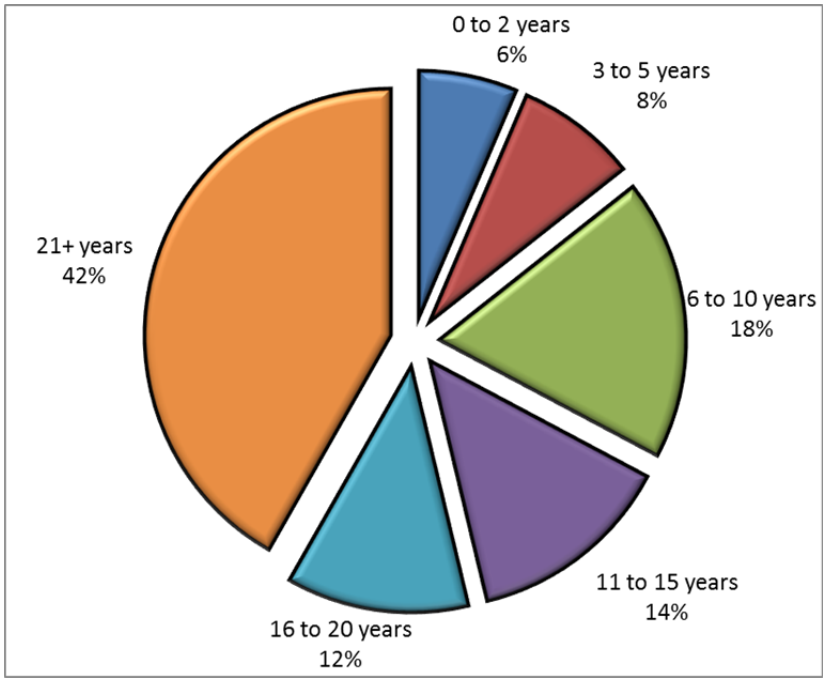

Figure 3. Breakdown of Participants by Experience Level for Experiment #1

3. Experiment #1—Theoretical Outcomes

The participants could choose the risk-free approach ($10 in expenses) or could take risk in which case there was a 50% chance that expenses would be $5 and a 50% that expenses would be $20. The number of possible solutions is shown in Figure 4. The "spider web" chart shows the cost variance (CV)[7] for each of the periods of the experiment. All solutions had a CV = 0 at the beginning of the experiment. Depending on the choice of risk versus no risk, and the 50/50 chance of either $5 or $20, the CV would go up or down over time. The maximum positive CV (budget surplus) was $30 and the maximum negative CV (budget overrun) was -$60.

7 Cost variance (CV) is the actual cost minus the budgeted cost. A positive CV is favorable, a negative CV is unfavorable, and CV = 0 is on budget.

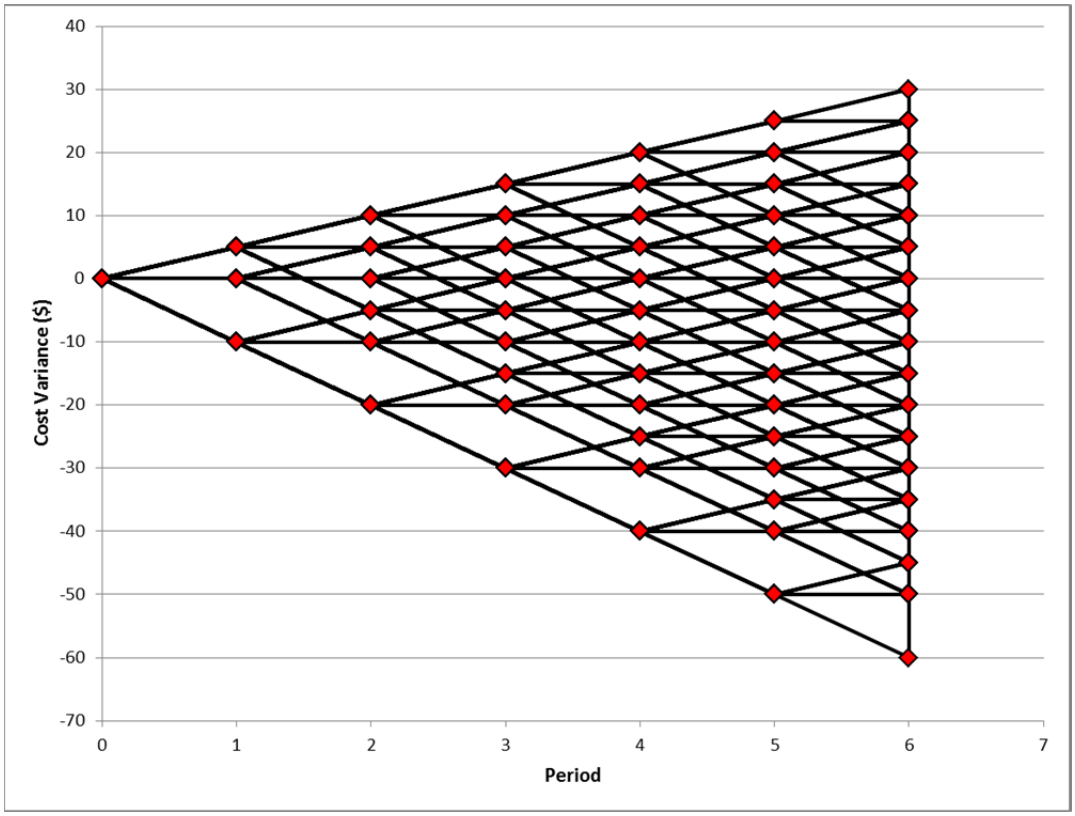

Figure 4. Possible Solutions for Experiment #1 (Cost Variances by Period)

Figure 4 shows the possible solutions, but not the distribution of solutions. For the participants who had a budget target of $60, if the participant decided not to take any risk, then the expected solution was a budget expense of $60 and a CV of $0 (see Figure 5). There was a 100% probability that the total expense would be $60.

For participants who had a budget target of $55, a risk-free approach resulted in a cost variance of -$5 (i.e., a cost overrun). The distribution of outcomes was the same as Figure 5 except that it was shifted by -5$.

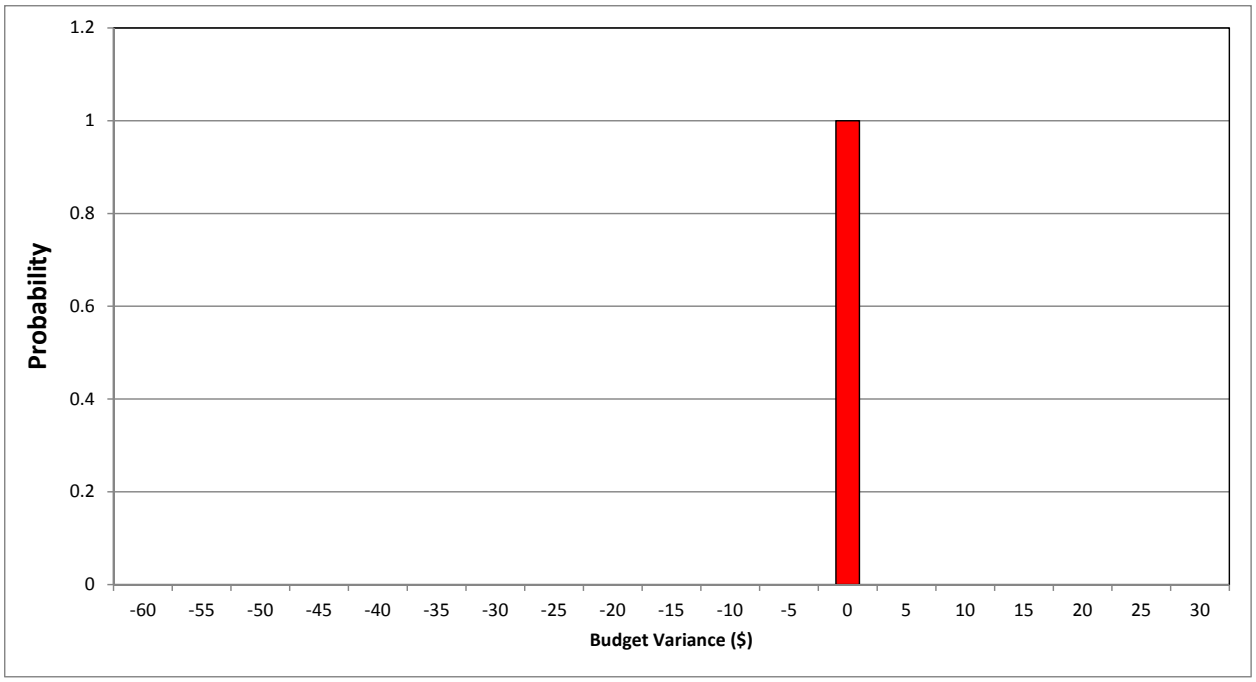

Figure 5. Distribution of Solutions for Experiment #1 When a Risk-Free Decision is Made for All Six Periods ($60 Cost Target)

However, if a participant who had a $60 cost target took risk at every opportunity, then the solution was a binomial solution with p = 0.5 (see Figure 6). Because the possible cost variance at each decision point was either +$5 or -$10, and there were six tasks subjected to risk, there were only seven possible outcomes. The mean cost variance for the distribution of outcomes was -$15 (a 25% increase in cost).

For participants who had a budget target of $55, the distribution of cost variances was shifted by -5$ (not shown).

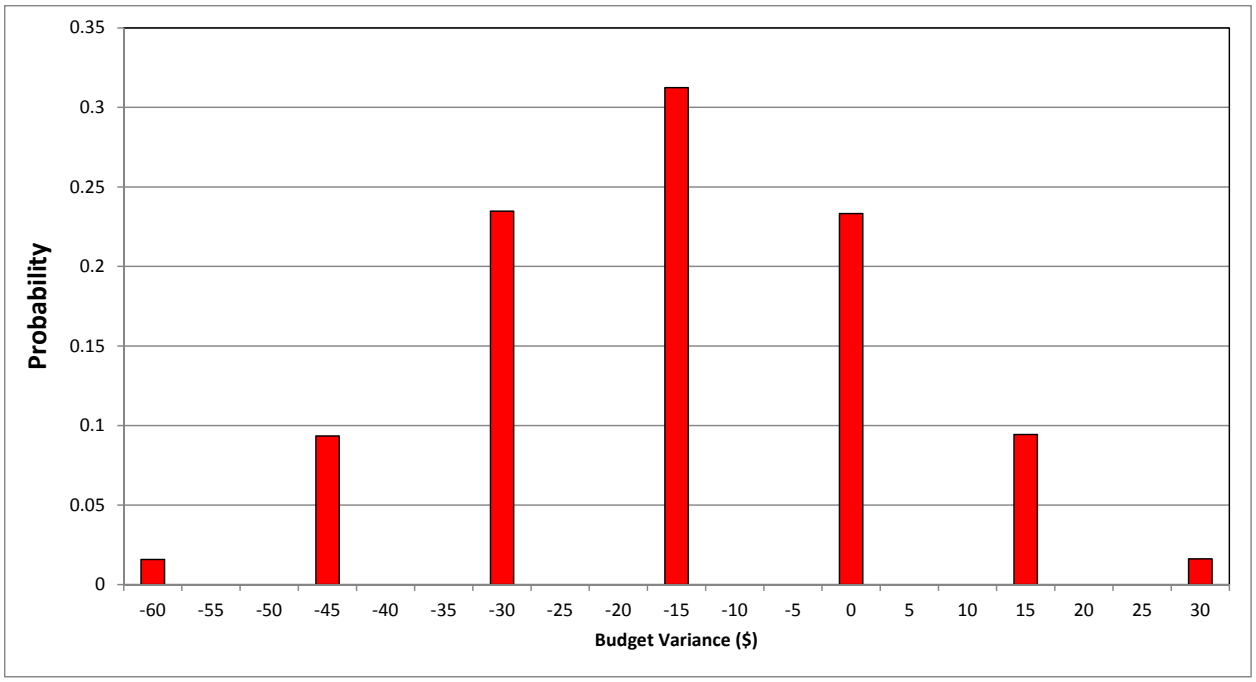

Figure 6. Distribution of Solutions for Experiment #1 When the Participants Always Choose the Risk Option for All 6 Periods ($60 Cost Target)

If the participant chose the risk-free option 33.3% of the time, and therefore, both of the random outcomes occurred 33.3% of the time, the distribution of final cost variances was a normal distribution with a mean of -$10 and a standard deviation of $11.1 (see Figure 7). The maximum CV was $30 (i.e., a budget surplus) and the minimum CV was -$60 (i.e., a cost overrun).

For participants who had a budget target of $55, the distribution of cost variances was shifted by -5$ (not shown).

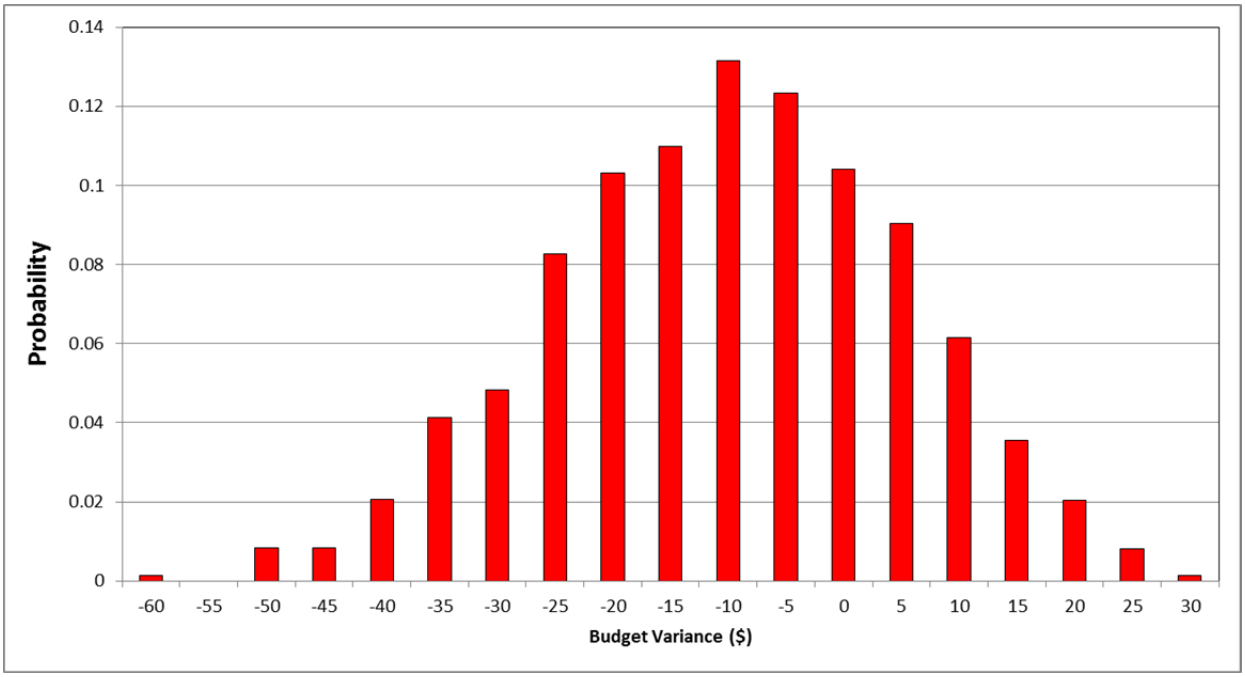

Figure 7. Distribution of Solutions for Experiment #1 When All the Solutions Are Equally Likely ($60 Cost Target)

4. Experiment #1—Results

The experimental data was analyzed to understand the following:

1. How likely was the participant to take risk?
2. How likely was the participant to take risk when the participant's cost variance was positive (i.e., when the participant's program was under budget/favorable)?
3. How likely was the participant to take risk when the participant's cost variance was negative (i.e., when the participant's program was over budget/unfavorable)?
4. Does the propensity to take risk vary by career field?
5. Does the propensity to take risk vary by the years of experience?

Four hundred and sixty-seven (467) people participated in the study. The data was analyzed at every period to determine how likely the participants were to take on risk as their actual costs met, exceeded, or under-ran their monthly budgets. That

is, for every period, the participant's risk taking as a function of cost variance was quantified.

The risk-taking behavior is very interesting. When the program was on budget, the participants took risk only 42% of the time (see Figure 8).

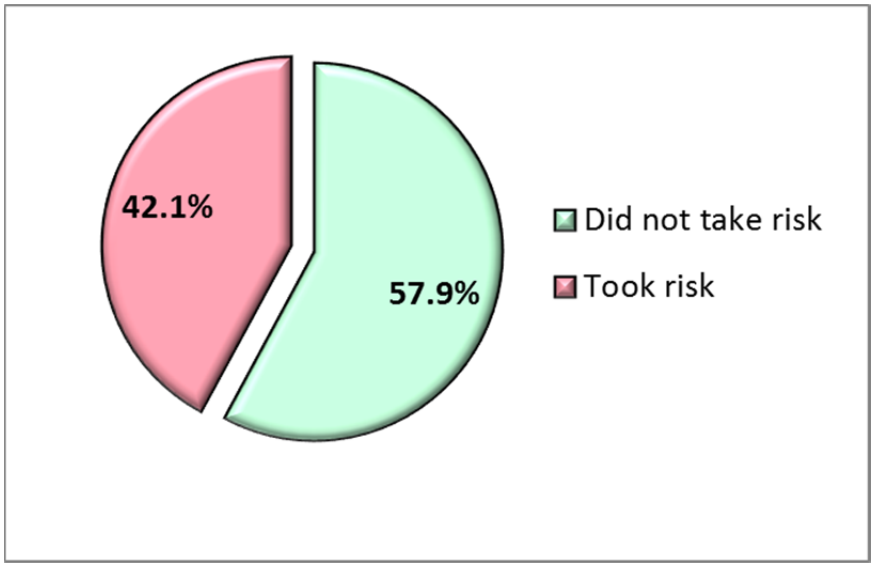

Figure 8. Risk Taking by the Participants who Had a CV of 0 (i.e., On Budget)

However, if the program was over budget (i.e., if the program's CV was negative), then the participants took risk 75% of the time (see Figure 9).

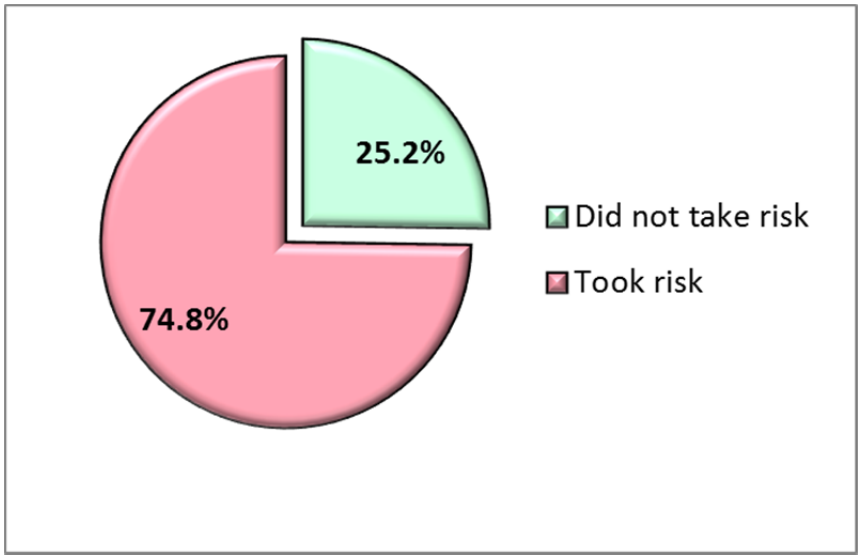

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Figure 9. Risk Taking by the Participants who Had a Negative CV (i.e., Over Budget)

If the program was under budget (i.e., the program's CV was positive), then the participants took risk 70% of the time (this value is statistically different from the "over budget" value at the 99.7% confidence level). See Figure 10.

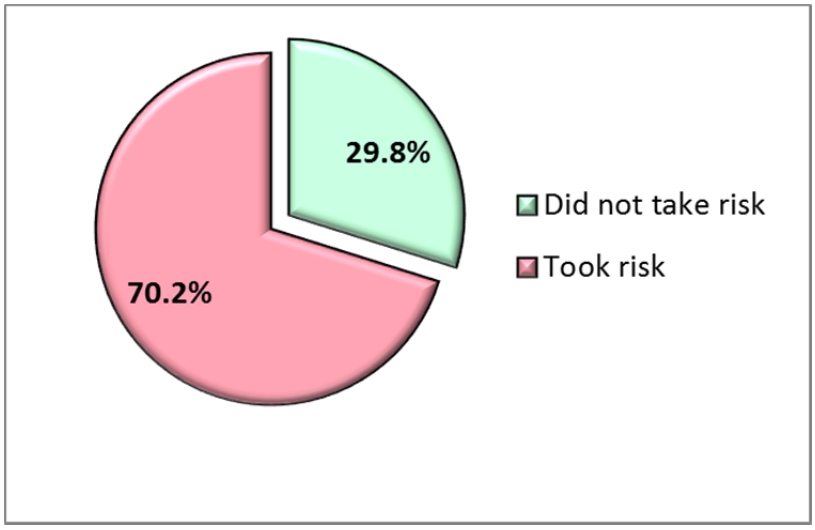

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Figure 10. Risk Taking by the Participants Who Had a Positive CV (i.e., Under Budget)

The experiment did not determine the reasons for taking risk when under budget. One possible explanation for risk-taking for people over budget is that they took risk in order to get back on target.

For those under budget, one possible explanation for risk taking is that the participants' attitude towards risk changed when they were under budget. More specifically, when they were under budget, they could afford to task risk. Another possible explanation is that a participant had taken risk previously and had been successful and, therefore, the participant was hopeful of another favorable result.

5. Experiment #1—Risk Taking by Career Field

Figure 11 shows the overall risk taking by career field. The y-axis is the probability of someone in that career field taking risk under any situation. The data labels above the bars are the number of people in that group. The average risk taking for all acquisition positions was 66%.

Career fields that had a higher level of risk taking compared to the average are LOG, CON, PQM, and "Other."[8]

Participants in the SPRDE and PM career fields took risk at a level below the average.

8 Other includes auditing, facilities engineering, industrial property, and purchasing.

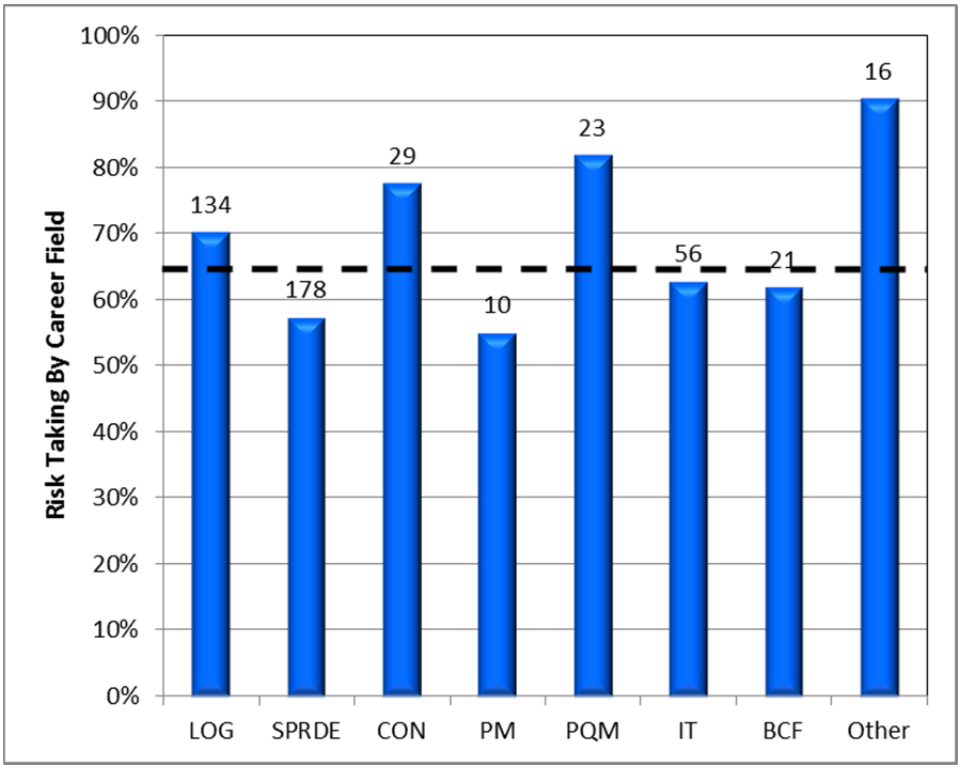

Figure 11. Overall Risk Taking by Career Field

Figure 12 shows how often people in the major DAWIA career fields took on risk depending on the status of the simulated program. The green bars show the risk taking that occurred when the program was under budget, the red bars show the risk taking when the program was on budget, and the blue bars show the risk taking that occurred when the program was over cost.

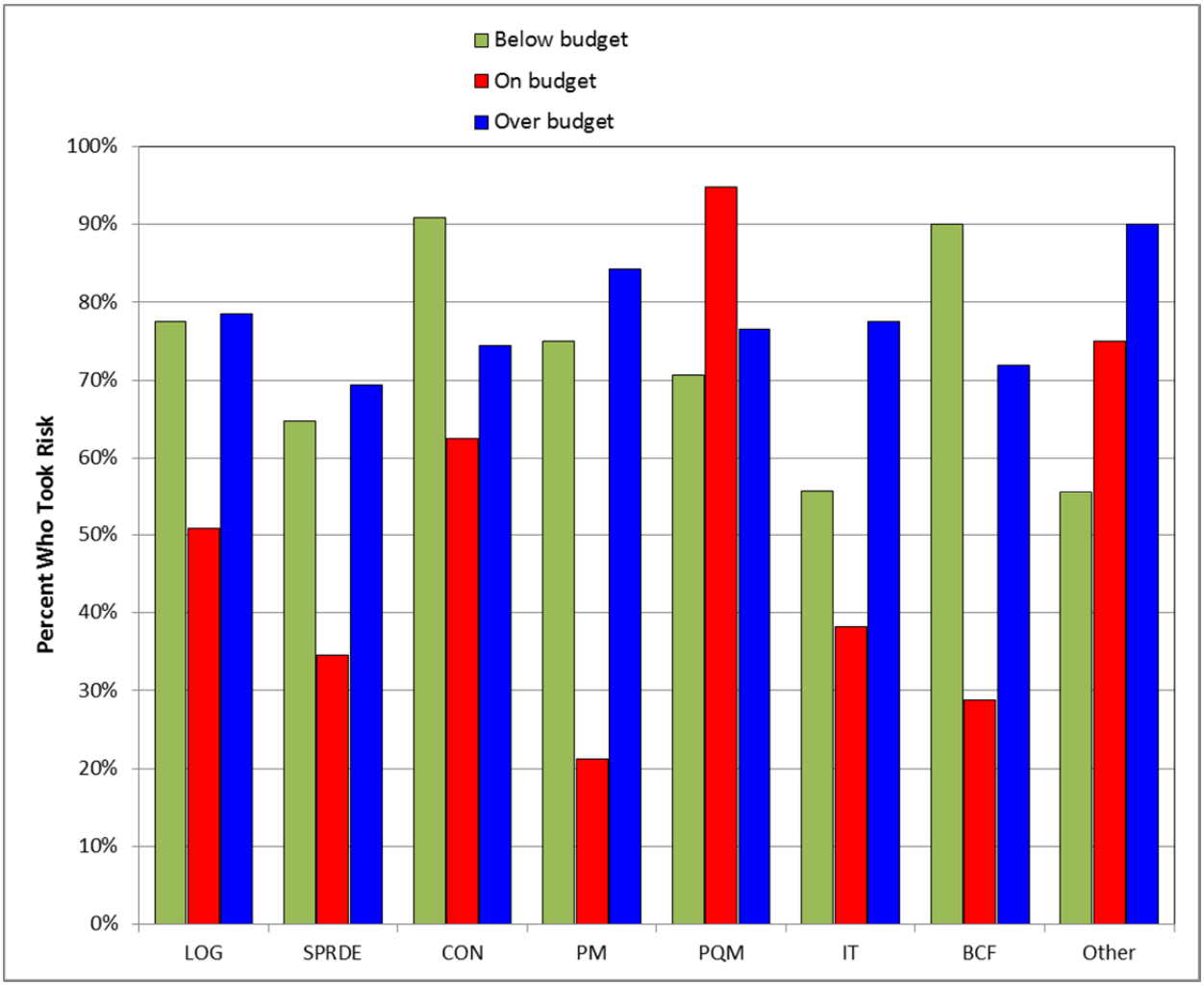

Figure 12. Risk Taking by Career Field When the Program Was Below, On, or Over Budget

For most of the career fields—LOG, SPRDE, CON, PM, IT, and BCF—the risk taking when the programs were on budget was lower than when it was above or below budget.

When the actual costs exceeded budget (i.e., CV was negative), most career fields showed an increase in risk taking. But most participants took an equal amount of risk if they were under budget.

However, the PQM career field does not fit the trend of the other career fields. For PQM professionals, they took on more risk when the program was on budget than when it was under or over budget.

The career fields included in "other"[9] showed greater risk taking when the program costs were above budget.

6. Experiment #1—Risk Taking by Experience Level

Figure 13 shows the overall risk taking by years of experience. The y-axis is the probability of someone taking risk under any situation. The participants have been separated into six groups with varying levels of experience: 0 to 2 years, 3 to 5 years, 6 to 10 years, 11 to 15 years, 16 to 20 years, and 21 years and above.

The data labels above the bars are the number of people in that group. The average risk taking for all acquisition positions was 66%.

There is not a strong relationship with years of experience. A linear regression of the full dataset shows a 0.12% change per year with a R^2 of 0.0012. Hence, there is no statistically significant relationship between risk taking and years of experience.

9 This includes auditing, facilities engineering, industrial property and purchasing, and test and evaluation.

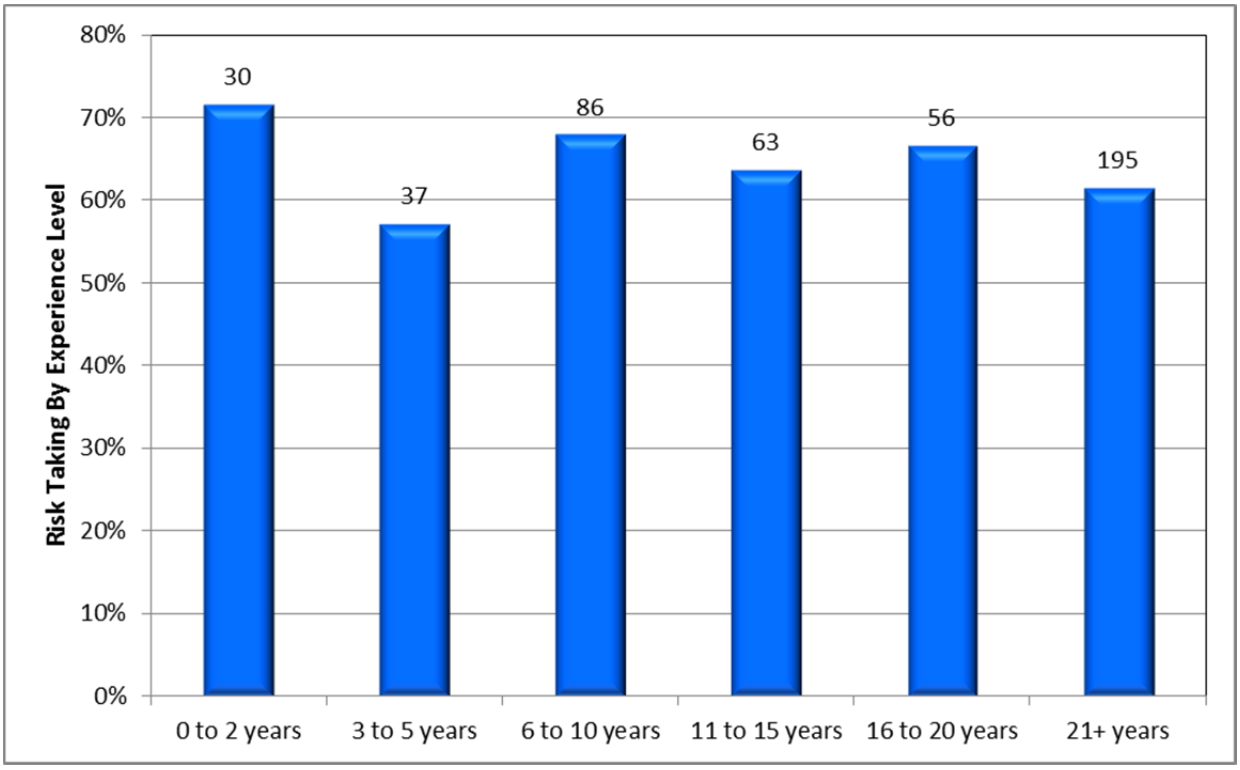

Figure 13. Risk Taking by Experience Level

B. Experiment #2

The second experiment was designed to validate the results of the first experiment regarding risk/rewards. The experiment was run for three classes from October 3, 2011, until March 25, 2012. Ninety-eight (98) students participated from ACQ-201B, SAM-301, and SYS-203 classes.

The experiment took about 10 minutes to complete, and participants kept track of their decisions on forms that the researcher then used to analyze the results. Students also provided their DAWIA career field and their number of years of work experience.

The target total expense for all of the participants in Experiment #2 was $50 (this differed from Experiment #1).

Each participant was faced with five decisions.[10] The participant started with zero actual costs and had five periods of expenses. If a risk-free approach was taken, each period's expense was $10. Therefore, if the participant took the risk-free approach for all five decisions, the participant would accumulate a total expense of $50 and would meet their budget objective (CV = 0).

However, at each decision point, participants could elect to take on risk to try and reduce their actual expenses. When the participant took risk, there was a 50% probability (p = 0.5) that the month's expenses would be $8, and there was a 50% probability that they would be $14. The expected outcome[11] of taking risk was $11. The full range of possible total expenses was from $40 to $70.

At each decision point, the participant could select the risk or risk-free approach. That is, the participants were free to change their strategy at each of the five decision points. If they took risk for each period, the participants would be over budget by an average of $5. Since there were only five trials, some participants "beat" the odds and came in under budget, while others were over budget.

There was a small reward offered to people who met or came in under the target expense of $50. There was an incentive to at least meet the target expense of $50. Prizes ranged from PEZ candy dispensers to coffee mugs. The person with the lowest total expense was the first to select their prize.

1. Experiment #2—Participants by Career Field

The distribution of the participants in Experiment #2 (see Figure 14) was higher for SPRDE, LOG, and IT and lower for CON and PM, compared to the overall population of the DAWIA workforce (shown in Figure 1).

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10 In the experiment, each decision was for one month of a program.

11 Expected outcome is what the outcome would be if a very large number of trials were undertaken. In this case, the expected outcome is 0.5*$5 + 0.5*$20.

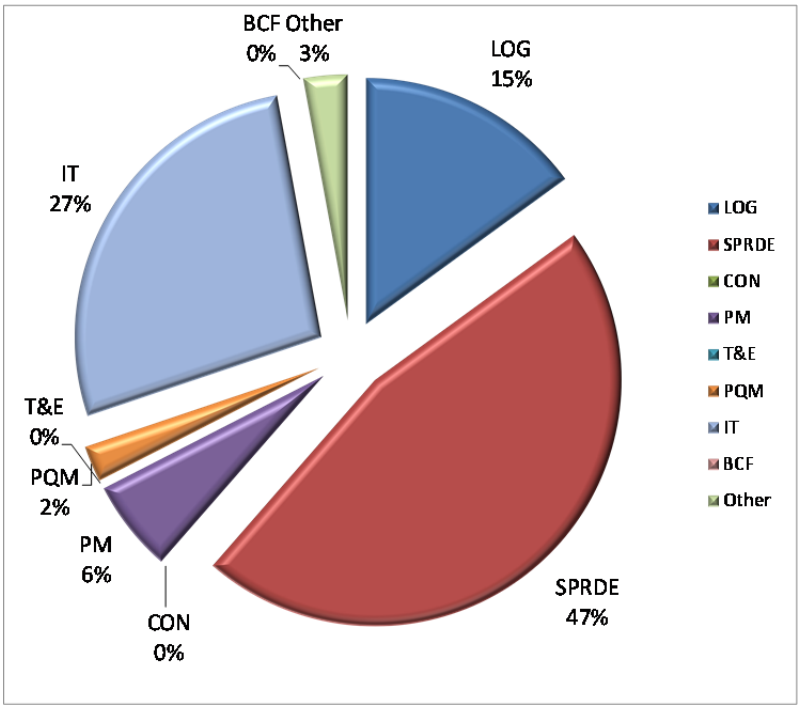

Figure 14. Breakdown of Participants Participating in Experiment #2 by Career Field

2. Experiment #2—Participants by the Number of Years of Experience

The total number of years of professional experience, either in the civilian government workforce, the military, or any industry, averaged 12.3 years. The distribution is shown in the following figure. Twenty-six percent (26%) had 21 or more years of experience and an equal number had two or fewer years.

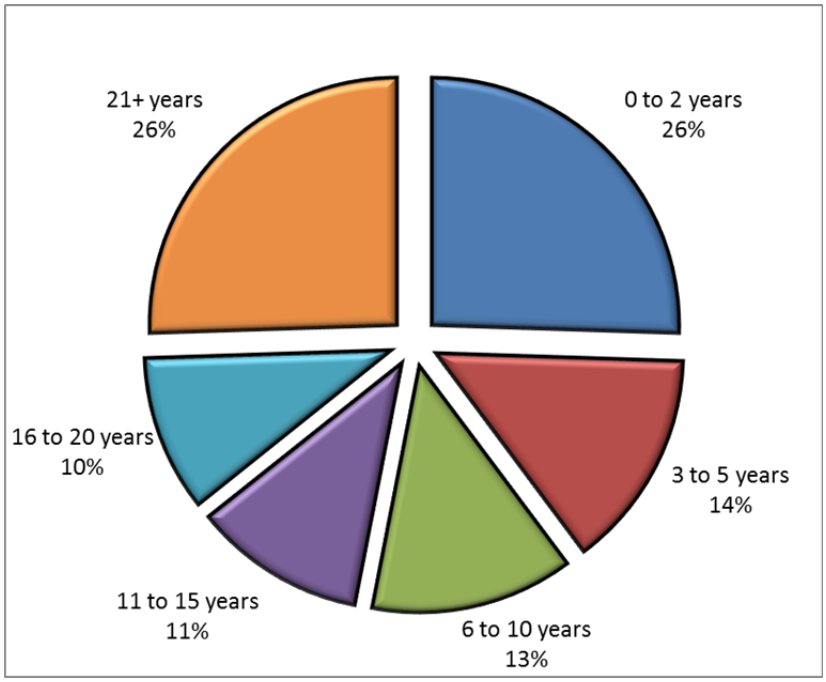

Figure 15. Breakdown of Students Participating in Experiment #2 by Experience Level

3. Experiment #2—Theoretical Outcomes

The participants could choose the risk-free approach ($10 in expenses) or could take some risk, in which case there was a 50% chance that they would have an expense of $8 and the other 50% of the time an expense of $14. The number of possible solutions is shown in Figure 16. The "spider web" chart shows the cost variance (CV)[12] for each of the periods of the experiment. All solutions have a CV = 0 at the beginning of the experiment. Depending on the choice of risk versus no risk, and the 50/50 chance of either $8 or $14, the CV could go up or down over time. The maximum positive CV (budget surplus) was $10 and the maximum negative CV (budget overrun) was -$20.

12 Cost variance (CV) is the actual cost minus the budgeted cost. A positive CV is favorable, a negative CV is unfavorable, and CV = 0 is on budget.

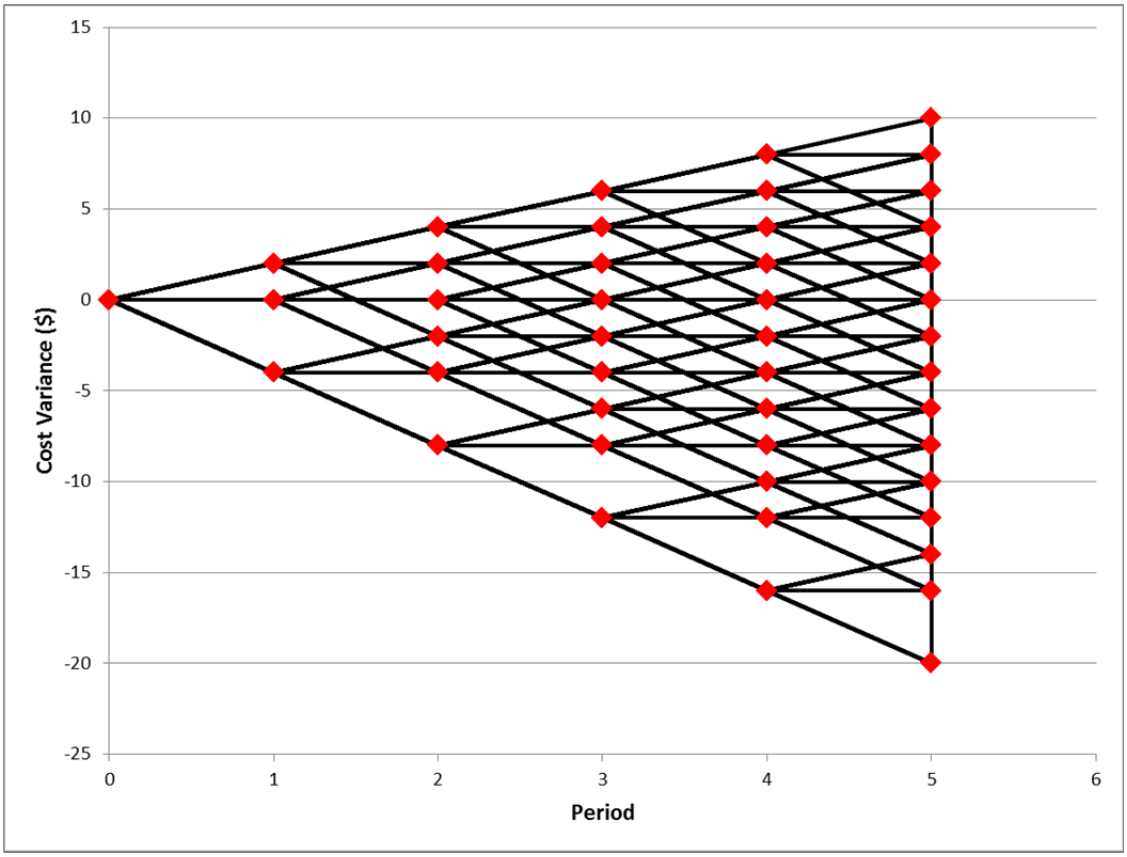

Figure 16. Possible Solutions for Experiment #2 (Cost Variances by Period)

Figure 16 shows the possible solutions, but not the distribution of solutions. If a participant did not take any risk, then the expected solution was $0 CV (see Figure 17). There was a 100% probability that the total expense would be $50.

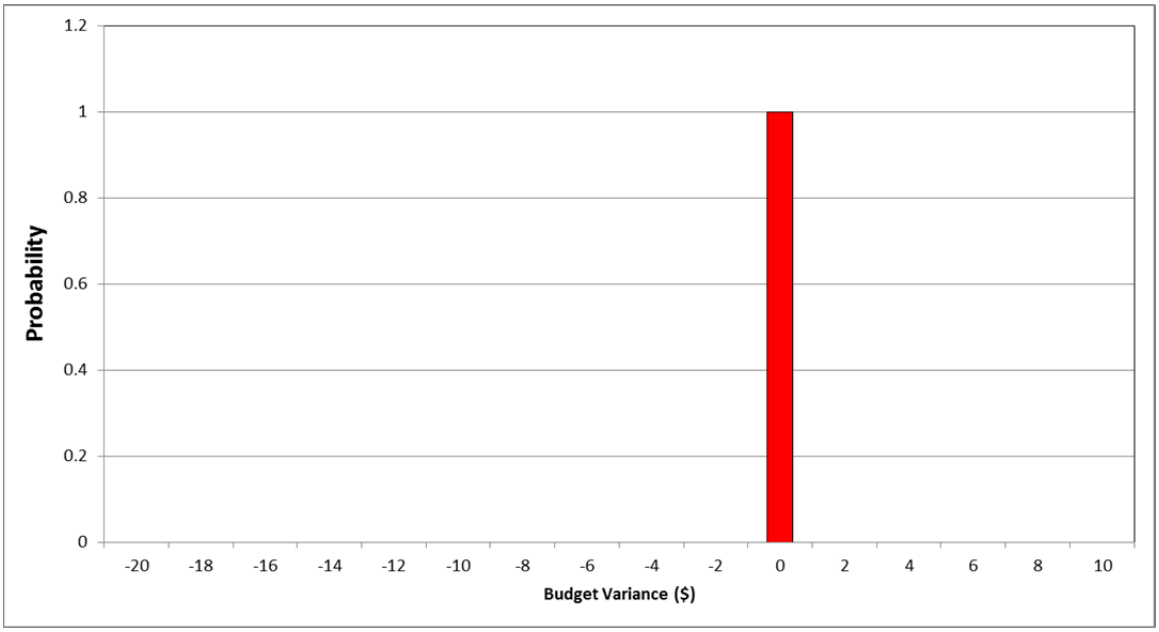

Figure 17. Distribution of Solutions for Experiment #2 When the Risk-Free Decision is Made for Every Period

However, if a participant took risk at every opportunity, then the solution was a binomial distribution with p = 0.5 (see Figure 18). Because the possible cost variance at each decision point was either +$2 or -$4 and there were five tasks subjected to risk, there were only six possible outcomes. The mean cost variance for the distribution of outcomes was -$5 (a 10% increase in cost).

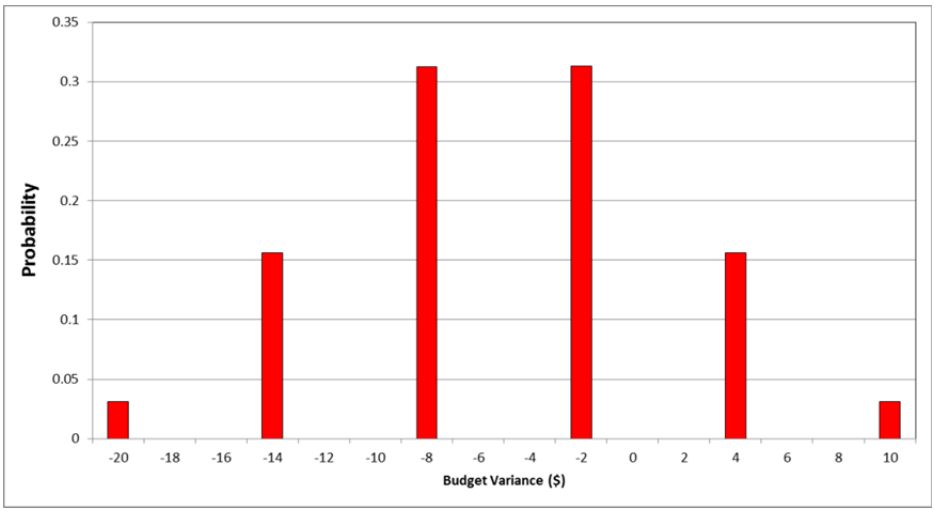

Figure 18. Distribution of Solutions for Experiment #2 When the Participant Always Chose the Risk Option

If the participant chose the risk-free option 33.3% of the time, in which case there was a 50% chance that they would have an expense of $8 and the other 50% of the time an expense of $14, the distribution of final cost variances was a normal distribution (see Figure 19).

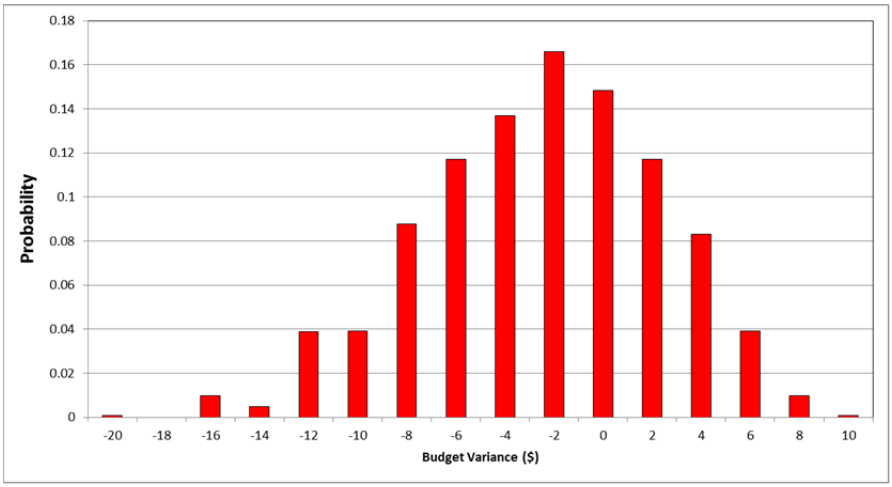

Figure 19. Distribution of Solutions for Experiment #2 When All the Solutions Are Equally Likely

4. Experiment #2—Results

The experimental data was analyzed to understand the following:

1. How likely was the participant to take risk?
2. How likely was the participant to take risk when the participant's cost variance was positive (i.e., when the participant's program was under budget/favorable)?
3. How likely was the participant to take risk when the participant's cost variance was negative (i.e., when the participant's program was over budget/unfavorable)?

Ninety-eight (98) people participated in Experiment #2. Their overall willingness to take on risk was examined and is shown in the following three figures. At every interval, the risk taking as a function of cost variance was quantified. When the program was on budget (at any point in the simulation), the participants took risk

64% of the time (see Figure 20). With a 50/50 chance of a cost increase for each period, 32% of the programs would go over cost during the period.

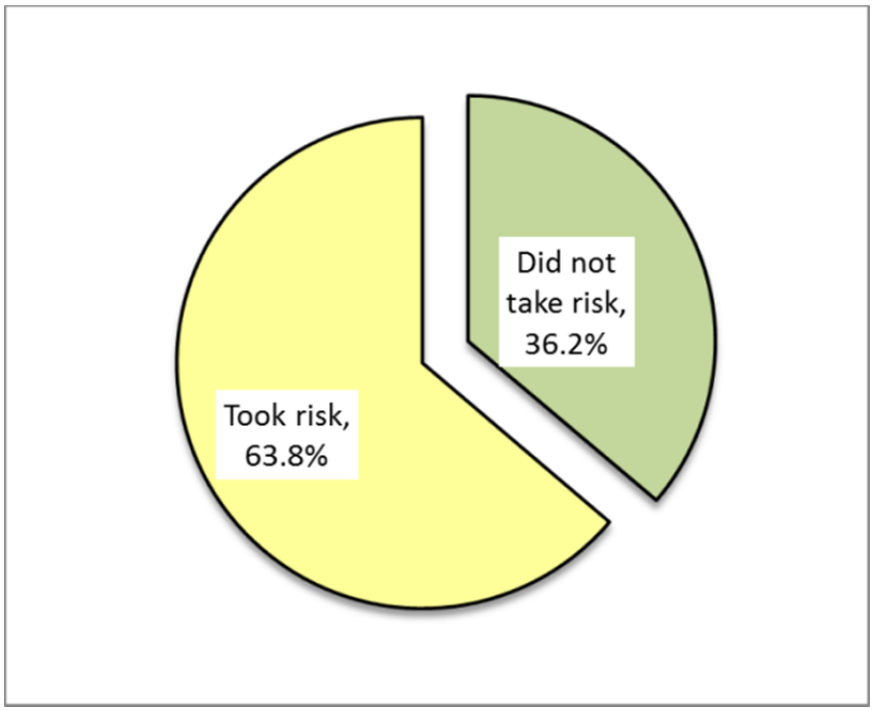

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Figure 20. Percentage of People Who Took On Risk With a CV of 0 (i.e., On Budget)

However, if the program was over budget (i.e., if the program's CV was negative), then the participants took risk 95% of the time (see Figure 21). The experiment did not determine the reasons for taking risk when over budget. One possible explanation for risk-taking is that they took risk in order to get back on target.

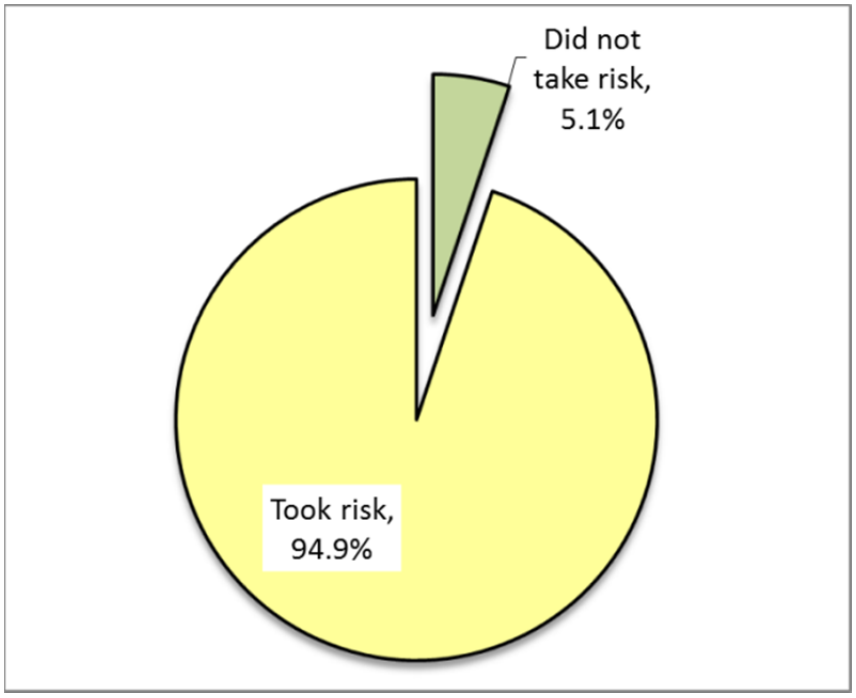

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Figure 21. Percentage of People Who Took On Risk With a Negative CV (i.e., Over Budget)

If the program was under budget (i.e., the CV was positive), then the participants took risk 89% of the time (see Figure 22). The experiment did not determine the reasons for this behavior. One possible explanation for risk taking is that the participants' attitudes towards risk changed when they were under budget. More specifically, when they were under budget they could afford to take risk. Another possible explanation is that participants had taken risk previously and had been successful and, therefore, they were hopeful of another favorable result.

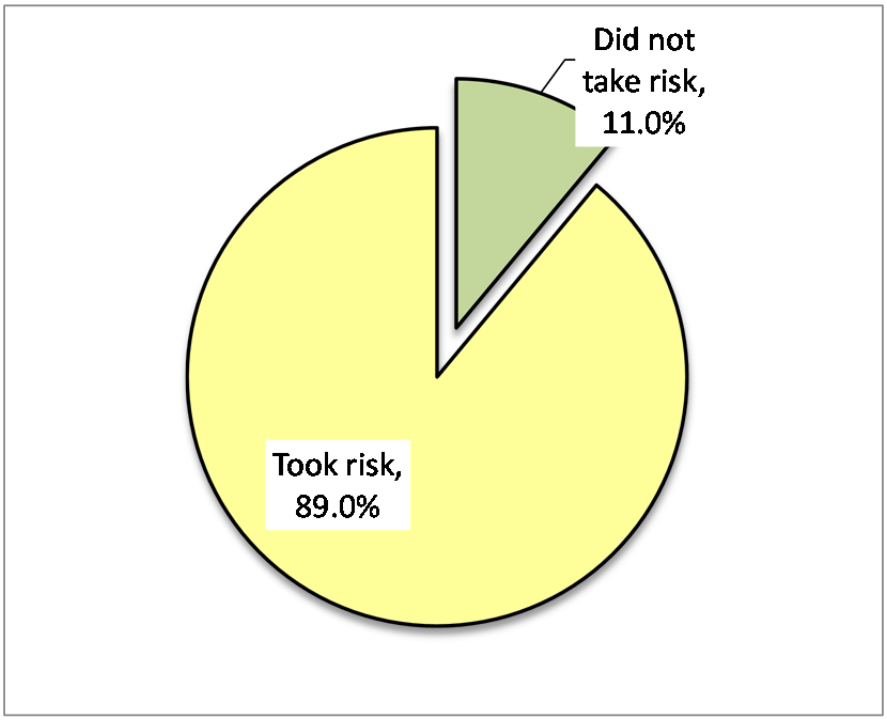

Figure 22. Percentage of People Who Took On Risk With a Positive CV (i.e., Under Budget)

V. Conclusions and Recommendations

Two research experiments were run to assess the DoD workforce's attitude to risk management. Experiments were selected to measure the decisions made by the participants in simulated situations. These experiments provide an objective measure of the workforce's attitude toward risk management.

Both experiments were designed to measure the participant's decision-making behavior when faced with uncertain outcomes. The second experiment also included a small reward to determine if a reward impacted the findings of the first experiment.

The experiments were run with DoD acquisition workforce members attending a DAU class. The experience level of the participants was high, with an average of 16 years of total work experience.

A. Finding 1 (Experiment #1)

Based on the results of Experiment #1, the DoD acquisition workforce exhibited risky decision-making even when "programs" were on budget. Experiment #1 found that 42% of the time, the workforce member took risks even when they were on track to complete the project on budget.

B. Finding 2 (Experiment #1)

Based on the results of Experiment #1, the DoD acquisition workforce took risk 75% of the time when their "program" was over budget.

C. Finding 3 (Experiment #1)

Based on the results of Experiment #1, the DoD acquisition workforce took risk 70% of the time even when their "program" was under budget.

D. Finding 4 (Experiment #1)

Based on the results of Experiment #1, there is no statistically significant relationship between years of experience and risk taking.

E. Review (Experiment #1)

Experiment #1 did not attempt to understand the reasons for the risk-taking behavior exhibited by the acquisition workforce.[13] When a program/project/task is over budget, there is the desire to get back on budget even though the participant knows that there is a chance that the situation will become worse. In the experiment, there was a 50/50 chance that things would improve. In real-life scenarios, the chance for success could be much less, making risk taking an even worse decision.

When a program was on budget in Experiment #1 simulations, there was still a relatively high (42%) level of risk taking by the participants.

When a participant's program was under budget, it was very surprising to find that 70% of the participants took risk even though they knew there was only a 50/50 chance of success. A possible explanation is the attitude that since they were under budget, they could afford to take risk. Another possible explanation is that participants had taken risk previously and had been successful and, therefore, they might have ignored the 50/50 chance of a cost increase.

F. Experiment #2

Experiment #2 differed from Experiment #1 primarily due to an award to the participants who met or came in under their budgeted cost.

13 Understanding the reasons for the risk-taking behavior would be an interesting follow-on research project.

G. Finding 1 (Experiment #2)

Based on the results from Experiment #2, the DoD acquisition workforce exhibited risky decision-making even when "programs" were on budget. Experiment #2 found that 64% of the time, the workforce member took risks even when they were on track to complete the project on time. This level of risk taking is a 52% increase from Experiment #1.

H. Finding 2 (Experiment #2)

Based on the experimental results, the DoD acquisition workforce took risk 95% of the time when their "program" was over budget. This level of risk taking is 27% higher than Experiment #1.

I. Finding 3 (Experiment #2)

Based on the experimental results, the DoD acquisition workforce took risk 89% of the time even when their "program" was under budget. This level of risk taking is 27% higher than Experiment #1.

J. Review (Experiment #2)

Experiment #2 differed from Experiment #1 primarily due to an award to the participants who met or came in under their budgeted cost. The experiment showed an even greater level of risk taking by the workforce. When a participant was either under budget or over budget, there was a 27% increase in risk taking when there was a reward. When the participant was on track to meet the budget, there was a 50% increase in risk taking (from 42% to 64%) when there was a reward.

K. Recommendations for Training

The workforce has demonstrated risk taking even when the expected outcome will worsen the situation. The opportunity for a reward increased the level of risk taking by at least 27% (relative to risk taking when a reward was not offered).

Based on these results and general discussions with people involved in risk management, additional risk management training should cover the following topics:

1. Basic probability training (~1 hr)
2. Review of economic risk & reward (~ 2 hr)
3. Basic business case analysis (~1 hr)
4. Review of the risk management process (specifically focused on identification, analysis and mitigation planning) (~2.5 hr)
5. Simulated decision-making (~1.5 hr)
6. Case studies (~2 hr)

The total recommended training is 10 hr with the training customized for the organization using case histories and the organization's risk management process.

L. Recommendations for Future Research

The big unanswered question is "Why?" The risk-taking behavior of the DoD workforce has been studied, but the reasons for the risky behavior have not been determined. Finding some or all of the root causes will enable more effective training and risk management.

In addition, there was not a negative outcome in the two experiments. Hence, the risk taking when there are positive and negative outcomes may differ from the findings of this research study.

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